

Cloud Property and Surface Radiation Observations and Diagnostics in Support of EOS;  
CERES, MODIS, and MISR Validation Efforts  
Status Report

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We have been quite active in validation activities during the past year. As discussed in our statement of work for year 4, our emphasis during the past 12 months has been directed at

1. Collection of ground-based and aircraft data at the University of Utah Facility for Atmospheric Remote Sensing (FARS) in direct support of Terra overpasses (with occasional *in situ* support provided by the SPEC Inc. Lear Jet) and
2. Facilitating validation of Terra data and products with data collected at the ARM clouds and radiation test bed (CART) sites.

We have attended three Terra-related meetings where we have presented results of our validation activities. These include,

1. MODIS Atmospheres science team meeting, January 2001 at NASA Goddard
2. CERES science team meeting, January 2001 in Williamsburg, VA
3. Terra cloud mask intercomparison workshop, May 2001 at the University of Wisconsin, Madison.

At the MODIS and CERES science team meetings, we presented our most recent results (discussed below) on collection of data at FARS and in construction of a world wide web (WWW) site that organizes and presents information on Terra overpasses of the 4 ARM sites and FARS.

At the cloud mask meeting in Madison we also discussed our available correlative data products. Additionally, the PI of this project (Mace) assumed the lead on a project to quantitatively compare the cloud mask results from the various Terra radiometers using the ground-site active remote sensor data as ground truth. Our initial set of correspondences with the other investigators is included as attachments to this report. Initially we evaluated the overpasses at the ground sites for suitability in terms of view zenith, cloud type and data availability. This information is posted to a special WWW page linked to our primary Terra validation site.

In the remainder of this report, we will discuss briefly the FARS data activities and the WWW site development, contents, and our plans for maintaining the site.

### **Terra Validation Effort at FARS, 1 October 2000 to 14 August 2001.**

We have supported at FARS a total of 54 Terra satellite overpasses since 1 October 2000. Most observations have involved ruby (0.694  $\mu\text{m}$ ) polarization lidar plus passive visible, infrared, and microwave radiometer measurement periods bracketing the times of local mid-day (46 cases) and mid-night (8 cases) overpasses.

We have emphasized those atmospheric conditions that are likely to be challenging for Terra radiometers to infer cloud and aerosol characteristics, including thin cirrus, multi-layered cloud systems, and various types of aerosols. Of a total of 38 cases involving cirrus clouds, 10 were very thin/ broken cirrus, 8 cirrus plus low and/or middle level clouds, and 6 were cirrus plus significant aerosol loading. Of a total of 15 aerosol layers, 4 were boundary layer, 9 Asian dust, and 2 forest fire smoke.

Moreover, under certain conditions the ruby/passive data were supplemented by W-band Doppler radar (5 cases) and/or dual wavelength (0.532 and 1.06  $\mu\text{m}$ ) Polarization Diversity Lidar (9 cases) observations to provide extra information and cloud and aerosol properties.

In addition, we were successful in obtaining 4 cirrus cloud case studies with in situ support from the SPEC, Inc., Lear jet flying over FARS: 19 October, 22 November, 1 December 2000 (Figure 1-3), and 1 May 2001. An additional Lear jet study at FARS was performed on 16 October 2000, but not in conjunction with a Terra overpass.

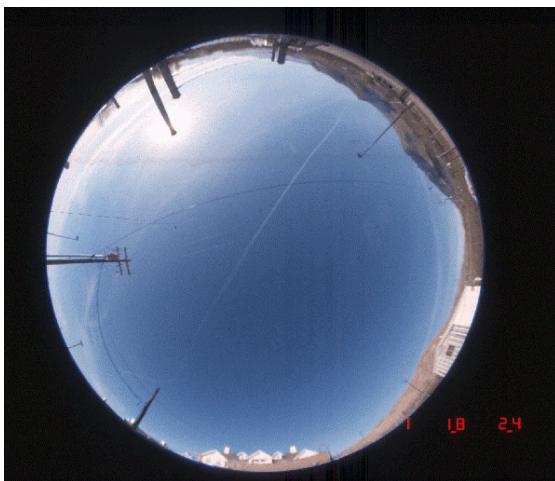


Figure 1. Fisheye photograph of cirrus during the Terra overpass of 1 December 2000. The contrail evident in the image is from the *in situ* Lear jet operated by SPEC.

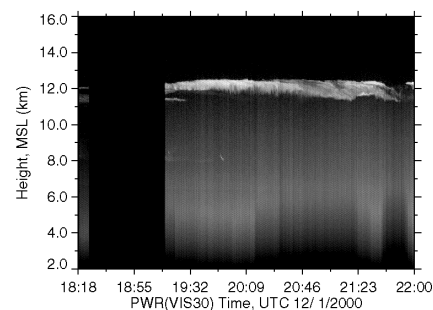


Figure 2. Height-time section of backscattered power from the visible channel of the polarization diversity lidar (PDL) collected on 1 December 2000 corresponding with the *in situ* support and Terra overpass.

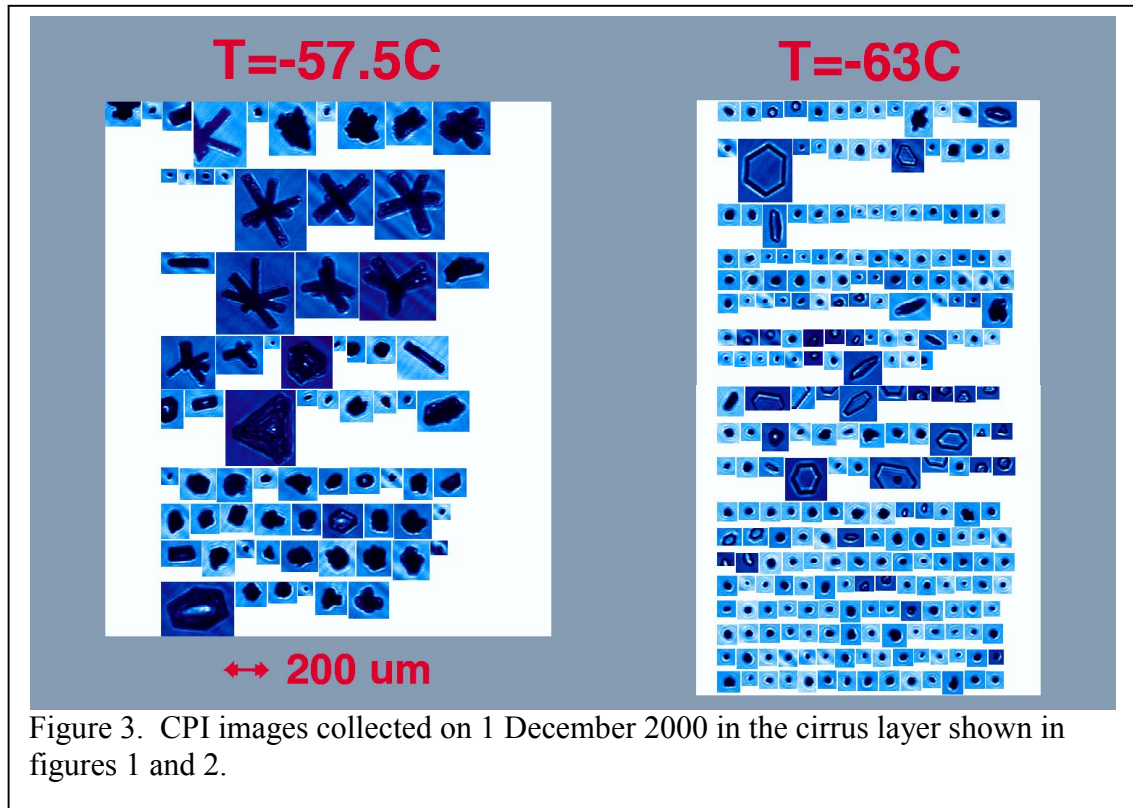


Figure 3. CPI images collected on 1 December 2000 in the cirrus layer shown in figures 1 and 2.

### The Univ. of Utah Terra Validation WWW Site

The EOS Validation Web Site, located at: <http://www.met.utah.edu/mace/homepages/research/eos.html> provides access to Terra overpass information and validation data files for the ARM and FARS sites.

We maintain an archive of the Terra overpasses over the four ARM sites. Each week the NORAD two-line Keplerian element (TLE) sets are downloaded from JPL. SatTrack (v3.1), a real-time satellite tracking and orbit prediction program for UNIX platforms, uses the TLE to run the SGP4 model for satellites in low-earth orbit to calculate Terra's overpass time and viewing angle over each ARM site.

Although all overpasses over the ARM sites are archived, only the overpasses with a viewing angle less than or equal to 50 degrees are selected for validation file creation.

The validation time interval begins 1.5 hours before and ends 1.5 hours after the Terra satellite overpass time. The ARM data within this time interval is regridded to a 10 second time and 50 meter height resolution. Each data point on the validation grid is assigned the value of the nearest neighbor ARM data point. A null data value is assigned if an ARM data point is not found within 1 minute or 50 meters of the validation grid point.

Table 1 shows the ARM data included in the validation files. We are working now to include in these files, cloud property retrievals for cirrus and stratus cloud layers.

Table 1. data included in the Terra validation subsetting ARM data files available from the University of Utah.

INTRUMENT	DATA
Millimeter-Wavelength Cloud Radar (MMCR) and other active remote sensors (VCEIL, MPL)	LASER Cloud Base Height Radar First Layer Cloud Top MMCR Radar Reflectivity MMCR Reflectivity Clutter Flag
Radiometric Instrument Systems Total Upwelling Solar (SIRS/SKYRAD/GNDRAD)	Total Downwelling Solar Liquid Water Path 23.8 GHz Sky Brightness Temperature 31.4 GHz Sky Brightness Temperature IR Brightness Temperature Wet Window Flag
Surface Meteorology (BMET/SMOS/SMET)	Dew Point Surface Pressure Temperature Relative Humidity Precipitation Total Wind Speed Wind Direction Vapor Pressure
Merged Sounding (RAOB, MWR, SMET)	Temperature profile Pressure profile Mixing Ratio profile

The Terra overpass information and graphical summaries of the validation files for the ARM sites are available on the EOS Validation Web Site.

Buttons on the EOS Validation Web Site home page allow the user to select the ARM site and year of the validation data. Once the site and year are selected, the user is presented with a yearly calendar page containing links to individual day pages. When the mouse passes over a day with a link, a small window opens up with a summary of that day's overpasses with viewing angle less than 30 degrees. The summary includes a cloud description, radar image, overpass time, and viewing angle. Clicking on the day's link will bring up that individual day's page.

Each individual day page contains a table of the overpass times with viewing angle less than or equal to 50 degrees and graphical summaries of the ARM data for the validation time interval. The validation netcdf files are available through email request.

Another way to access the individual day pages is through the web site's cloud description tables. Buttons on the EOS Validation Web Site home page allow the user to select the ARM site and year for cloud description tables. These tables provide the Terra overpass information and cloud characteristics for overpasses that are less than 30 degrees. The dates in the table are linked back to the individual day pages described above.

Through browsing the EOS Validation Web Site, the user is able to view Terra overpass information and graphical summaries of the ARM data collected during a 3 hour time interval surrounding the Terra overpass.